

IMPROVEMENT OF PERFORMANCE MEASUREMENT SYSTEMS USING PRODUCTION MANAGEMENT DASHBOARDS

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ABSTRACT

The issue of performance measurement has been increasingly discussed by the academic community and professionals of most industries. The large amount of publications about this theme indicates its importance for business management and also the existence of gaps in knowledge. In Brazil, there has been an increasing interest from construction companies in improving their performance measurement systems. However, the characteristics of this industry make the development and implementation of performance measurement systems a relatively complex task. Previous research has pointed out the need for improving the use of performance measurement for decision making, by properly processing and analyzing existing data. One way of improving performance measurement systems is the development of performance dashboards, which allow a set of performance indicators to be monitored through a single interface. This paper proposes a set of guidelines for the conception and assessment of production management dashboards, as a mechanism for improving performance measurement systems for production management in construction. It is based on two action research empirical studies, which involved the development and implementation of production management dashboards in two different construction companies. The main contributions of this research study are: (a) criteria to assess the effectiveness of dashboards; (b) mechanisms for involving different management levels on the use of dashboards; and (c) guidelines for implementing dashboards.

KEY WORDS

dashboard, measurement systems, performance measurement, process transparency, production management

INTRODUCTION

The issue of performance measurement has been increasingly discussed by the academic community and professionals in different sectors of the economy, including the construction industry (Lantelme and Formoso, 2000; Neely and Najjar, 2006). The large amount of

publications, seminars and web pages on this topic is an indicator of such growth (Neely, 1999; Busi and Bititci, 2006; Beatham et al., 2005). However, Neely (2005) points out the repetition of studies focused in the same aspects concerning performance measurement. According to that author, the field of performance measurement is passing through a phase of empiric

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investigation of the existing systems and also theoretical verification of its core concepts.

Performance measurement plays a crucial role in business management, because it focuses people and resources on their most important aspects (Waggoner *et al.*, 1999; Lantelme and Formoso, 2000). A performance measurement system must reflect the company's main objectives as well as the context where it is inserted (Neely, 1999; Kennerley and Neely, 2003). However, in isolation such measures may not be able to provide enough information for decision making (Beatham *et al.*, 2004). Often, deviation in the results found in one indicator may be the sign of a problem in another process or the existence of problems due to different causes which need to be corrected (Beatham *et al.*, 2004).

Ghalayini and Noble (1996) and Samson and Lema (2002) suggest that performance measures must provide updated information to managers, supervisors and operators, which are required by their area or responsibility. Those measures have to be objective, simple, pro-active and of easy to understand by the interested parts, besides providing relevant, trustful and in timely information (Neely *et al.*, 1997).

In many companies, data that is necessary for decision making move on with certain difficulty, in a very slow and fragmented way, contrasting with the needs for a competitive and dynamic environment (Schiemann and Lingle, 1999). Kennerley and Neely (2003) highlight that the availability and the effective use of such measures help companies to be competitive in the market. Grief (1991) states that the way in which the indicators are made

available for the people in the organization may influence their interpretation.

In Lean Production systems, performance measurement plays an important role in terms of providing process transparency. It makes visible attributes that are usually invisible, and helps the employees to see how they are performing, creating conditions for decentralized control to be implemented (Lantelme and Formoso, 2000).

According to Manoochehri (1999), the users' needs must be considered in the definition of the content, timing, and frequency of reports. Information must be available in an accessible format for the people in charge of decision making (Grief, 1991; Samson and Lema, 2002). Kennerley and Neely (2003) also highlight the need to understand the benefits of performance measurement in order to get managers more involved in the achievement of the objectives of the organization. In fact, leaders play a key role in the success of the implementation of a performance measurement system (Waggoner *et al.*, 1999; Ghalayini *et al.*, 1997; Bourne *et al.*, 2002; Schiemann and Lingle, 1999; Lantelme and Formoso, 2003; Beatham *et al.*, 2005).

In Brazil, the construction industry has showed an increasing interest in improving their performance measurement systems, due to several changes that are happening in this sector, such as the demand for quality management certification, the adoption of profit sharing reward policy by some companies, and the growing number of construction companies that sell shares in the stock market. Nevertheless, in most construction companies there is a shortage of

performance measures that effectively support decision making (Costa et al., 2006). As stated by Mohamed (1996), this lack of data may be due to the peculiarities of the construction activity, which makes it difficult for data produced at the operational level to be quickly collected. As a consequence, decisions are frequently based on administrators' intuition and experience, and not on data systematically collected (Lantelme and Formoso, 2000).

Neely and Bourne (2000) and Bourne et al. (2002) pointed out that there is a need for improving the use of performance measures in decision making, through the analyses and extraction of maximum value from data. Beatham et al. (2004) suggest that measures must be clustered in order to create a unified and well-balanced system, including financial and non financial indicators, related to both products and processes, for evaluating either their efficiency or efficacy. One way of improving performance measurement systems is the development of a performance dashboard, which can be used for monitoring and connecting a set of indicators by using a single interface (Orts, 2005; Krauss, 2005). This paper proposes a set of guidelines for the conception and assessment of production management dashboards, as a mechanism for improving performance measurement systems for production management in construction.

PERFORMANCE DASHBOARDS

There are many definitions of a dashboard, each one within a specific area (for example, economy, publicity and engineering). Few (2006) and Middleton (2005) highlight that

effective dashboards provide important data in a way that they can be rapidly read and understood, also showing how to relate some metrics to others, in order to reach the financial goals. Shermach (2005), in turn, suggests that through a dashboard, staff members can stay in touch with the strategic direction of the company and present their contribution to it. Eckerson (2005) states that the dashboard communicates the strategic goals and provides the means for measuring, monitoring and managing critical processes aiming to reach those goals. According to the same author, the dashboard provides timely and relevant information so that directors, managers and other staff members can measure, monitor and manage their progress towards reaching their strategic goals (Eckerson, 2005).

In a dashboard, the monitoring of critical processes is done using key performance indicators (KPIs) that trigger alerts when the results are below the expected (Eckerson, 2005). Dashboards are an option for improving information availability and to make the decision making process more effective (Malik, 2005). Through different levels of detail, the information can be accessed in a condensed or an aggregated manner, depending on the need of the users (Eckerson, 2005). Besides, the cause of the problems can be analyzed, based on different sources of information compiled by a single tool (Eckerson, 2005).

Eckerson (2005) emphasizes the advantages of using dashboards. These advantages are similar to the ones pointed out by Kaplan and Norton (2004) regarding Balanced Scorecard and by Chiapello and Lebas (1996) regarding the *Tableau de Bord*. The

dashboard: (a) translates strategy into objectives, metrics and initiatives customized for each team in the company; (b) provides information that can be used to refine strategies, allowing the managers to make corrections in the actions of the company to reach their strategic goals; (c) increases the visibility of future performance through the collection of relevant data that allow the projection of scenarios based on past activities; (d) reduces the cost and the redundancy through of standardization of information, making possible to eliminate parallel information systems; (e) creates conditions to give more autonomy to users, since it provides direct access to information; (f) provides information rapidly reachable, gathered in the same local. In short, according to Eckerson (2005), the dashboard must deliver the right information to the right users at the right time, in a way that provides more favorable conditions for decisions making, enhances efficiency and anticipates the production results.

Concerning to Eckerson (2005) and Few (2006), the applications of a dashboard may be divided in three: monitoring, analysis and management. Each application provides a specific set of functionalities, communicated in different ways (Eckerson, 2005; Few, 2006). The first application is related to monitoring the process and the critical activities of the business, using performance metrics that trigger alerts when potential problems arise. The second application seeks to analyze the root cause of problems by exploring relevant and timely information from multiple perspectives and at various levels of detail. In the last one, the broader application supports the managing of people and processes,

aiming to improve decisions, optimize performance and steer the organization in the right direction.

There are also three types of dashboard: operational, tactical and strategic (Few, 2006; Eckerson, 2005; Chiapello and Lebas, 1996). Each type of panel emphasizes the three levels of information and the three applications described before in order to differentiate them. The operational dashboard monitors the main operational processes, being used mainly by production staff or their supervisors. This type of panel provides, above all, detailed concise information. The operational dashboards emphasize more the monitoring than the analysis and management (Eckerson, 2005).

A tactic dashboard is focused on departmental processes or projects inserted in a certain segment of the organization, limited to a specific group of people. According to Eckerson (2005), company managers use a tactical dashboard to compare the performance of their area or project with the established goals, the projections and the results of the period before.

By contrast, a strategic dashboard monitors the execution of strategic objectives. Its goal is to align the efforts carried out by different areas of the company with those strategic objectives. Eckerson (2005) highlights that a strategic dashboard must give managers a better visibility of the operation and identify the main performance boosters (key drivers). The strategic dashboard emphasizes management more than monitoring and analysis.

RESEARCH METHOD

Action-research was the research strategy adopted in this study. It is a strategy for obtaining knowledge and for changing social systems at the same time. Typically it involves a cyclic process that consists of the diagnosis of the problem, planning, action, and an assessment of the results. In this approach, the main focus of the investigation is the result of an intervention in the subject being studied (Eden and Huxham, 1996). It is important to point out that this research study had an exploratory character, since it involves an issue that has not been properly explored in construction management.

Two empirical studies were carried out in different construction companies, in which a performance dashboard was developed and implemented by a team of production managers with the support of one of the researchers. The development of those studies was triggered by an initial motivation of the authors on studying this topic and also by a demand from the two companies for improving their performance measurement systems. Company B is a medium sized construction company most involved in commercial and industrial projects for private clients. Company C is a large construction company that develops and builds residential building projects, mostly for middle and higher middle class clients. In both of them the dashboard was developed for production management, since this was the area

that most needed improvements in performance measurement.

The research study was divided into three main stages: preparation, development and implementation, and data analysis and reflection (Figure 4). In the first stage, the performance measurement systems of four companies (including companies B and C) were analyzed. Company A only participated in an exploratory study, in which data collection tools were tested. The fourth company, named Company D, was not from the construction sector, and had been chosen because it had a well developed performance dashboard. A set of constructs and variables was defined in order to structure data collection in the empirical studies and also to help in the assessment of the development, use and improvement of dashboards. The definition of those constructs was based on the literature about dashboards and from the information obtained in the preparation stage, especially in the interviews carried out in companies B, C and D.

At the end of the preparation stage, the first cycle of reflection (that characterizes action-research) took place. As a result, the constructs were refined, and a proposal for an action plan was prepared by one of the authors, based on improvement opportunities observed in companies B and C. This plan was discussed with managers from each of those companies. At the end of this phase both companies B and C had a plan of activities for the development and implementation of a production management dashboard.

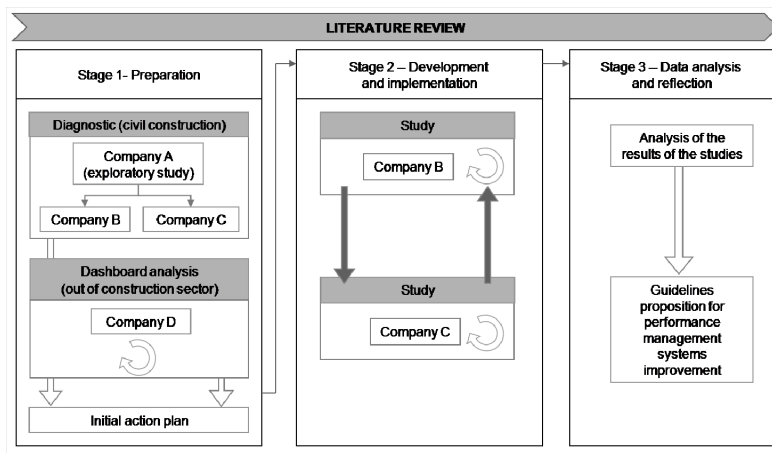


Figure 4: Research method chart.

The implementation stage consisted of the implementation of the action plan, which involved the introduction of changes in the companies' daily organizational routine. Due to the simultaneity of the studies in companies B and C, there were learning opportunities between the two companies, even considering that they work in very different market segments. At the data analysis and reflection stage, additional data were collected through participant observation in meetings, semi-structured interviews, and the organization of assessment seminars which involved several production managers from each company.

RESULTS

PREVIOUS SITUATION

Before the development of the study, in Company B a Project Performance Report was produced monthly by each site manager. This report was considered to be a kind of dashboard that contained information about project performance. There were nine indicators, which were grouped into three areas: production, quality and

safety. The dashboard had colorful visual alerts, which indicated whether the result was above or below the expected value. The colors (green, yellow or red) were defined by intervals of the expected values for the indicators. Moreover, in the lower part of the dashboard there was a space for the definition of mitigating actions for those indicators that were below the expected performance. Besides the operational dashboard, the company had also a tactical dashboard, which was a summary of all indicators from the operational dashboard, plus financial metrics. Data collection and analysis was not well formalized, and many inconsistencies were found on the way indicators were produced in different construction sites.

Company C had an operational dashboard developed by one of the production managers, as part of his Master's dissertation. In that study, a set of performance measures for production management was defined and standardized. The information for the dashboard was generated monthly by the site manager of each construction site. Five metrics were monitored: cost deviation, time

deviation, percentage of plan concluded (PPC), site management good practice index and volume of residues. They were summarized in the report, using colors (green, yellow or red) to indicate whether the performance was within the expected interval. A monthly meeting was held for the analysis and discussion of the performance indicators of all sites. This meeting was chaired by the two production managing directors, and had the participation of all site managers, the planning engineer, safety manager and material supply managers. Each site manager had to make a presentation about the situation of his/her project, pointing out existing problems and, if necessary, proposing actions to improve the current situation. The main objectives of those meetings were to do a formal and systematic discussion of performance measures, creating an opportunity to share information and discuss problems that were common to different construction sites, as well as to provide some feedback to the directors.

CHANGES INTRODUCED IN THE COMPANIES

A number of improvements were introduced in the performance measurement system of each company, focused on the role of the performance dashboards. All of them were defined by a working team that was formed in each company, involving a group of managers and one of the authors. The main improvements are presented below:

- Revision of the set of metrics: the main changes were concerned with the alignment of the metrics with the company strategy, and improving the

consistency of the description of each indicator. The definition of each measure was made systematic by using the following elements, as proposed by Neely et al. (1997): definition, aim, data collection procedure, and goal. The alignment of the set of metrics with the strategy was obtained by drawing a network containing the main elements of the production strategy of the company as well as the critical processes. As a result, the indicators included in the dashboard were clearly related to either the production strategy or the critical processes, and each of them had a well defined goal;

- Improvement on the configuration of the dashboard: the configuration of the dashboard was improved by separating information according the managerial level of the users (operational, tactical or strategic). Moreover, improvements were made on the way data were displayed by using graphs and colors. The good practices that were observed in Company D were helpful for establishing those improvements;
- A structured agenda for discussing the dashboard in the production management meetings: along the study, the working team felt that there was a need to formalize specific moments in the meetings for discussing the tactical and strategic dashboards. In this discussion an internal

benchmarking was carried out between different sites; and

- Establishment of a procedure for data collection and analysis: this procedure included all the steps that were necessary for producing the required information within a monthly cycle, the people in charge of the different steps, and the deadlines. It is concerned with the

production of all dashboards (operational, tactical, and strategic). An important issue involved in this procedure was the need to provide transparency for all people involved, so that data collection and processing was consistent over all projects.

As an example, Figure 2 shows the tactic dashboard developed in Company C.

DASHBOARD													
		LOGO OF THE COMPANY			LOGO OF THE SITE 1			LOGO OF THE SITE 1			LOGO OF THE SITE 1		
month		XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	
year		month CD	annual CD	month CD	annual CD	month CD	annual CD	month CD	annual CD	month CD	annual CD	month CD	
CD (cost deviation)	↑	XX		XX		XX		XX		XX		XX	
goal < or = 1		month CD		annual CD		month CD		annual CD		month CD		annual CD	
TD (time deviation)	↓	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
goal > or = 1		month TD	global TD	month TD	site TD	month TD	site TD	month TD	site TD	month TD	site TD	month TD	site TD
PPC (percentage of plan concluded)	↑	XX%		XX%	XX%	XX%	XX%	XX%	XX%	XX%	XX%	XX%	XX%
goal xx%		global average PPC		month PPC	site PPC	month PPC	site PPC	month PPC	site PPC	month PPC	site PPC	month PPC	site PPC
NR18 (site management good practice index)	→	XX%		month INR18	XX%	month INR18	XX%	month INR18	XX%	month INR18	XX%	month INR18	XX%
goal > or = xx%		global average INR18		month INR18	XX%	month INR18	XX%	month INR18	XX%	month INR18	XX%	month INR18	XX%
VR (volume of residues)	↑	XX		XX		XX		XX		XX		XX	
goal < x.xxx m³/m²		site average VR		site VR		site VR		site VR		site VR		site VR	

Figure 2: Dashboard developed in Company C

FACILITATING FACTORS AND DIFFICULTIES FACED BY THE COMPANIES

Table 1 presents a summarized description of the facilitating factors

and the difficulties found in the development and implementation of performance dashboards for production management in Companies B and C.

Table 1: Facilitating factors and difficulties faced by companies B and C

	Company B	Company C
Facilitating Factors	<ul style="list-style-type: none"> • Previous development of other academic studies in the company; • Existence of a performance measurement system, including a kind of dashboard; • Existence of a formal and well disseminated strategic plan up to the level of contract manager; • Little resistance to changes; • Commitment from different areas and managerial levels; • Group commitment. 	<ul style="list-style-type: none"> • Previous development of other academic studies in the company; • Existence of a performance measurement system, including a kind of dashboard; • Understanding of the meaning of existing indicators; • Commitment of different managerial levels; • Existence of standardization and systematization of processes.
Difficulties	<ul style="list-style-type: none"> • Lack of understanding about the meaning of some indicators; • Low level of process standardization; • Insufficient depth in the definition of action plans. 	<ul style="list-style-type: none"> • Lack of dissemination of the corporate strategic plan; • Lack of commitment of medium level managers; • Considerable resistance to changes; • Insufficient depth in the definition of action plans.

GUIDELINES

Based on the literature review and also on the results of the empirical studies, a set of six guidelines for the implementation of dashboards for production management in construction companies were proposed: (a) set up a team involving people from different sectors from the company; (b) get support and commitment from top and medium-level managers; (c) prepare users for the correct manipulation of the dashboard; (d) define a coordinator for the process of data collection, processing and analysis that results from the use of the dashboard; (e) formalize the moments of analysis; and (f) map and systematize the data collection and analysis process for the dashboard. In fact, these guidelines are not limited to the implementation of dashboards, but are also related to the implementation of improvements in

performance measurement systems in a broader sense.

CONCLUSION

The seven constructs that were established in this paper may be used in the assessment of efficacy of dashboards in other companies. The constructs are: (a) horizontal and vertical scope; (b) systematization; (c) support for decision making; (d) standardization; (e) transparency; (e) strategic alignment of indicators; and (f) connection between the indicators. The utility of such constructs was made evident along the empirical studies carried out in this research. They also helped to structure data collection, allowing the comparison between the dashboards of the companies, in the definition of the modifications proposed for them and in the evaluation of the results. Based on those evidences, it was observed that this set of constructs represents a

group of characteristics which are required for an effective dashboard. Therefore, they may be used as criteria for the conception of dashboards and for the assessment of their efficacy.

Breaking down into strategic, tactical and operational levels enabled the companies to establish a connection of those different managerial levels to the dashboard. The establishment of such connections makes it possible for top managers to follow the company's performance at operational and tactical levels, as well as, at the strategic one. This follow-up allows the monitoring of strategies' implementation at the operational level of the company. The process of dividing into hierarchical levels must take place from the top to the bottom, and, there is a need for information, such as reports, analysis and decisions, to run in both directions. Descendent information flows favor the alignment of operational units with the corporate

strategy, while the ascendant one allows the monitoring of different units or even the development of studies located in an unit (sector, department or construction site), which may be reproduced in large scale after being tested and validated.

A major conclusion of this research work was that the implementation of dashboards played an important role in inducing the improvement of performance measurement system of the companies involved, regarding the refinement of the set of indicators, implementation of standardized metrics that are systematically collected, and effective use of measures for decision making. Through the development of the dashboard, a performance measurement system that integrates key indicators for the management of production in a single data base was developed and implemented, as suggested by Costa (2003).

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